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STORAGE

CHOLAM (*A. SORGHUM*) AS A SUBSTITUTE FOR BARLEY IN MALTING OPERATIONS

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Assistants to the Government Agricultural Chemist, Madras

AGRICULTURAL RESEARCH INSTITUTE, PUSA

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CHOLAM (*A. SORGHUM*) AS A SUBSTITUTE FOR BARLEY IN MALTING OPERATIONS

BY

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AND

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[Received for publication on 1st July, 1918.]

AT the Madras Exhibition of 1917, the Government Agricultural Chemist exhibited a series of malted foods of the type of Benger's and Mellin's foods and Horlick's malted milk, which were prepared by the use of malt obtained from *cholam*[1] (*Andropogon Sorghum*) and *ragi* (*Eleusine coracana*). The use of these cereal grains for the preparation of malts was necessitated by the fact that barley is not produced in South India with the exception of a comparatively small quantity on the Nilgiri hills.

Experiments made in Europe and America with barley, maize, wheat, rye, and oats had shown that barley was the grain best suited for purposes of malting. The malting values of the various grains examined were[2] :—

Barley	...	...	...	1·00
Oats	...	...	...	0·30
Maize	...	...	...	0·28
Rye	...	...	...	0·93
Wheat	...	...	...	1·08

Wheat malt, though slightly better than barley, has been discarded for general use as being too costly, so that barley is the grain almost universally employed for malting purposes.

[1] Synonyms :—
English—Great millet.
North Indian—Juár.
Tamil—Cholam.
Telugu—Jonna.
Kanarese—Jolah.
Burmese—Pyoung [Watt. *Dict. Econ. Prod. India.*]

[2] Martin, G. *Industrial Organic Chemistry*, page 286.

This paper deals with the investigations carried out with the object of finding a satisfactory substitute for barley from amongst the common South Indian cereals. The following obtained from the Central Farm, Coimbatore, were examined for their malting capacities: *paddy* (*Oryza sativa*), *cholam* (*Andropogon Sorghum*), *ragi* (*Eleusine coracana*), *tenai* (*Setaria italica*), *maize* (*Zea Mays*), and *cumbu* (*Pennisetum typhoideum*).

Preparation and Examination of the Malts.

The malts were prepared in each case in the laboratory in the following manner. A quantity of the grain was soaked in water for 12 hours, the water being removed twice during the period, at the end of which it was completely drained off. The swollen grains were then transferred to germinating trays, and germination was allowed to proceed as uniformly as possible. The temperature of germination was about 28°C. At the end of 60 hours, the radicles had developed to about 1½ times to twice the length of the grain, and the plumules were just showing up. The germination was, at this stage, arrested by cutting off the supply of moisture. The grains were first dried in the shade for a day, and then at 50°C. for two days in a draught oven. The radicles had, by this time, dried up, and could easily be removed by rubbing and sieving.

The degree of starch hydrolysis effected by each of the malts was taken as the basis in estimating their relative efficiency. Two methods were adopted in determining the activity of the malts in the starch solution so that the one might be a check against the other. They were (*a*) titration of the products of hydrolysis of starch against Fehling's solution, and (*b*) the testing of the products of hydrolysis by their colour reactions with iodine, these reactions being blue when starch is present, red, violet, or purple when dextrine is present, yellowish when hydrolysis is almost complete, and colourless or yellow when hydrolysis is complete.

The malts were ground in a laboratory mill and 3 grams of each were extracted with 50 c.c. of distilled water for 5 hours at the laboratory temperature (28°C.–30°C.) and filtered through a dry filter. Ten c.c. of the filtrate were added to 50 c.c. of a 2 per cent. solution of Lintner's soluble starch and kept for one hour at room temperature. At the end of this period further diastatic action was stopped by raising the solutions to the boil and, after cooling, they were made up to 100 c.c. and titrated against Fehling's solution. The figures obtained required a correction due to the reducing power of the malt extract added. This was determined in each case by means of a blank

experiment with the malt extract alone and the corrected values corresponding to the actual products of hydrolysis were then deduced.

TABLE I.

Showing the relative efficiency of various malts as judged by Fehling's solution.

Malts	Total reduction values in terms of c.c. Fehling's solution	Reduction values of malt extracts used in terms of c.c. Fehling's solution	Corrected reduction values in terms of c.c. Fehling's solution	Relative efficiency. Cholam = 1·00
Cumbu	47·6	8·3	39·3	0·71
Maize	52·1	9·4	42·7	0·78
Tenai	56·8	5·9	50·9	0·93
Cholam	66·7	11·6	55·1	1·00
Paddy	66·7	9·4	57·3	1·04
Ragi	80·0	19·7	60·3	1·09

Malt extracts prepared in the same manner were similarly treated with soluble starch in test tubes and tested with iodine at intervals of quarter of an hour with the following results :—

TABLE II.

Showing hydrolysis of starch as judged by colour reactions with iodine.

Name of malt	Colour reactions with iodine at the end of			Inference
	15 minutes	30 minutes	45 minutes	
Cumbu ...	Blue	Blue	Blue	Hydrolysis incomplete, starch present.
Tenai ...	Blue	Blue	Blue	Ditto.
Cholam ..	Violet blue	Yellowish	Yellow	Hydrolysis complete.
Paddy ..	Blue	Reddish blue	Reddish blue	Hydrolysis incomplete, dextrine present.
Ragi ...	Violet blue	Yellowish	Yellow	Hydrolysis complete.

It will be seen from the above that the diastatic activity of *paddy, cholam,* and *ragi* is greater than that of *cumbu, tenai,* or *maize.* These latter grains

were, therefore, eliminated from further consideration, and the *paddy*, *cholam*, and *ragi* malts subjected to further comparative tests.

As a basis for the comparison of these grains, it was sought to determine approximately the stage of germination at which diastatic activity was at its maximum for each kind of grain and, with this object in view, samples were withdrawn from time to time during the course of germination and the following factors determined in each case :—

(*i*) The average length of the radicle.
(*ii*) The specific gravity of the aqueous extract.
(*iii*) The diastatic activity of the extracts when made under uniform conditions as measured by the iodine test.

The results (see Table III) show that *cholam* and *ragi* give an extract of greater specific gravity than paddy and at the same time their diastatic hydrolysis has been carried to completion whereas that of paddy has remained incomplete. Consequently they are better suited for malting than paddy which was, therefore, eliminated from further consideration. At this stage further experiments with *ragi* were also given up as it was considered that the smallness of the grain and its tendency to form a felted mass in the malting trays detracted from its usefulness as a malting grain.

TABLE III.

Showing the diastatic activity of Paddy, Cholam *and* Ragi *malts at different stages of germination.*

No. of hours from the time of soaking the grain	PADDY					CHOLAM					RAGI				
	Average length of radicle in c.m.	Sp. gr. of aqueous extract	COLORATION WITH IODINE AFTER			Average length of radicle in c.m.	Sp. gr. of aqueous extract	COLORATION WITH IODINE AFTER			Average length of radicle in c.m.	Sp. gr. of aqueous extract	COLORATION WITH IODINE AFTER		
			1½ hours	3 hours	4 hours			1½ hours	3 hours	4 hours			1½ hours	3 hours	4 hours
24	nil	0·9999	Blue	Blue	Blue	nil	0·9998	Blue	Blue	Blue	nil	0·9993	Blue	Blue	Blue
47	nil	1·0008	Blue	Blue	Blue	0·3	1·0031	Red	Reddish yellow	Yellowish	0·13	1·0050	Red	Reddish yellow	Yellowish
72	1·1	1·0019	Blue	Blue	Red with faint blue	2·0	1·0075	Yellowish	Yellowish	Yellow	1·10	1·0086	Yellowish	Yellow	Yellow
77	1·4	1·0037	Blue	Blue	Red	2·1	1·0086	Yellowish	Yellowish	Yellow	1·10			Sample lost	
83	1·4	1·0034	Blue	Red with faint blue	Red	2·4	1·0109	Yellowish	Yellow	...	1·30	1·0087	Yellowish	Yellow	...
95	2·3	1·0037	Reddish blue	Yellowish red	Yellowish	2·5	1·0091	Yellow	...	...	1·60	1·0105	Yellowish	Yellow	...
100	2·5	1·0030	Reddish blue	Yellowish red	Yellowish	...	...	...	...	..	..	...	...	...	...
118	2·9	1·0010	Red	Yellowish	Yellow	...	..	...	...	...	...	...	...	...	...
124	3·2	1·0030	Red	Yellowish	Yellow	...	...	...	...	...	...	...	...	...	..
141	3·5	1·0045	Red	Yellowish	Yellow	...	...	...	...	...	...	...	...	...	...

Cholam and Barley Compared.

The choice of a suitable grain being therefore restricted to *cholam*, the next step in our investigation was a comparison between *cholam* and barley, the former being the best suited South Indian cereal, and the latter the one most generally used by maltsters. The barley used for these experiments was obtained from the Kaity branch of the United Breweries, Ltd., Nilgiris, who had imported it from the Punjab.

Barley malt is generally prepared at a temperature of about 15°C., whereas the temperature actually available at Coimbatore is 28–30°C.; consequently, for purposes of comparison, barley and *cholam* malts were prepared—

(*i*) in a cool incubator at a temperature of 18–20°C., and

(*ii*) at the laboratory temperature of 28–30°C., and subjected to comparative tests.

The quality of a malt is usually judged from the quantity of water-soluble matter it is capable of yielding, and its degree of acidity in terms of lactic acid. It was, therefore, thought desirable at the outset to test our malts for these factors usually connoted by the term "soundness."

The water-soluble matter was determined by stirring up 25 grams of each malt with 200 c.c. of water which was brought to the boil and kept in the steam oven for one hour. After cooling, the volume was made up to 250 c.c., and the whole filtered through a dry filter. Fifty c.c. of the filtrate were evaporated to dryness and weighed, and the weight of the extract obtained was calculated to 100 grams malt.

Table IV.

Showing percentage of soluble matter in Cholam *and Barley malts.*

	Cholam	Barley
Moisture	5·29	5·95
Weight of dry residue in 50 c.c. filtrate	3·72	3·40
Weight of soluble matter in 100 grams malt	74·40	68·00
Weight of soluble matter calculated on the dry malt ...	78·50	72·30

The acidity of the malts was determined according to Allen's method[1] by extracting 50 grams of the ground malt with 100 c.c. of water for 30 minutes,

[1] Allen. *Comml. Organic Analysis*, vol. I, page 327.

filtering and titrating the filtrate against N/10 KOH with litmus as indicator.

TABLE V.

Showing acidity of Cholam *and Barley malts.*

Malt	Temperature of malting	Acidity calculated as per cent. lactic acid
Barley malt from Nilgiris	.....	0·19
Barley malt prepared in the laboratory	18—20°C.	0·19
Barley malt do.	28—30°C.	0·16
Cholam malt do.	18—20°C.	0·33
Cholam malt do.	28—30°C.	0·28
Cholam malt do.	28—30°C.	0·25

A malt is considered sound[1] when it yields about 70 per cent. of water-soluble extract, and contains less than 0·4 per cent. free acid (calculated as lactic acid), so that the malts which were prepared in the laboratory were sound in the technical sense, and the scope of the investigation was extended, therefore, to include the following :—

(*a*) Comparison between the diastatic activities of *cholam* malts prepared at two different temperatures, *viz.*, 18–20°C. and 28–30°C., and during various stages of germination.

(*b*) Comparison between the diastatic activities of *cholam* and barley malts prepared at 18–20°C. and 28–30°C.

(*c*) A preliminary investigation of the products of starch hydrolysis by *cholam* malt.

(*a*) *Comparison between the diastatic activities of* Cholam *malts prepared at two different temperatures and during various stages of germination.*

The malts were prepared in the manner already described at two different temperatures, *viz.*, 18–20°C. in a cool incubator, and 28–30°C. which was the laboratory temperature. At intervals during the process of germination samples were withdrawn, the length of the radicles measured, and the prepared malts were examined for their diastatic activity.

[1] Allen. *Comml. Organic Analysis*, vol. I, page 327. Also, Lunge. *Technical Methods of Chem. Analysis*, vol. III, part II.

TABLE VI.

Showing relative diastatic activities of Cholam *malts prepared at* 18–20°*C. and* 28–30°*C., and at different stages of germination.*

Hours after soaking the grain	Temperature of preparation 18—20°C.			Temperature of preparation 28—30°C.		
	Length of radicle in c.m.	c.c. sugar solution required for reducing 10 c.c. Fehling's solution	Colour reaction with iodine after 45 minutes' hydrolysis	Length of radicle in c.m.	c.c. sugar solution required for reducing 10 c.c. Fehling's solution.	Colour reaction with iodine after 45 minutes' hydrolysis
66	0·3	196·0	Blue	2·1	60·0	Bluish violet
90	1·0	132·0	Violet	3·3	52·0	Pale, but distinct violet
114	2·2	63·5	Very pale violet	7·5	55·0	Ditto.
138	3·6	54·0	Yellow	...	...	.....
162	...	57·0	Yellowish	...	...	.....

These results indicate that the diastatic activity reaches a maximum when the radicle grows to a length of about 3 c.m., and, as is to be expected, that the growth is quicker at a higher temperature than at a lower one.

(*b*) *Comparison between* Cholam *and Barley malts prepared at* (*i*) 28–30°*C. and* (*ii*) 18–20°*C.*

(i) 28–30°C.

Two grams of each of the *cholam* and barley malts prepared at 28–30°C. were extracted for 3 hours at room temperature with 100 c.c. of water, filtered, and 1 c.c. of each of the extracts was added to a number of test tubes containing 5 c.c. of 4 per cent. soluble starch and tested with iodine every quarter of an hour.

TABLE VII.

Showing the relative diastatic activities of Cholam *and Barley malts by iodine tests.*

Duration of experiment	Cholam malt	Barley malt
15 minutes	Violet with light blue	Blue
30 ,,	Violet with faint blue	Blue
45 ,,	Violet	Blue
60 ,,	Violet	Blue
75 ,,	Yellowish	Violet with light blue
90 ,,	Yellow	Violet with faint blue
105 ,,	.....	Yellow

Again 1 c.c. of each of the malt extracts was added to two separate lots of 50 c.c. of the soluble starch, and at the end of one hour hydrolysis was arrested by raising the solutions to the boil. The mixtures were cooled, made up to 100 c.c., and titrated against Fehling's solution.

TABLE VIII.

Showing the relative diastatic activities of Cholam *and Barley malts by the copper reduction method.*

Malt	c.c. sugar solution required for reducing 5 c.c. Fehling's solution	
	Experiment A	Experiment B
Cholam malt	16·5	16·5
Barley malt	13·0	13·0

(ii) 18–20°C.

Experiments similar to the preceding were made with *cholam* and barley malts prepared at 18–20°C., and the results are given below :—

TABLE IX.

Showing relative diastatic activities of Cholam *and Barley malts prepared at* 18–20°C.

Malt	c.c. sugar solution required for reducing 10 c.c. Fehling's solution	Colour reaction with iodine after 45 minutes' hydrolysis
Cholam malt	54·0	Yellow
Barley malt	52·5	Violet

The results tabulated in Tables VII, VIII, and IX show that *cholam* malt is diastatically more active than barley malt according to the iodine test. Quite the reverse, however, is indicated by the copper reduction method. This apparent discrepancy may be explained in the following manner.

It is possible that the hydrolysis of the starch takes place at a greater rate with *cholam* malt than with barley malt, and that comparatively more dextrine and less sugar are produced with the former than with the latter. It is also possible that the dextrine formed by the action of *cholam* malt belongs to the class of dextrines not precipitated or coloured by iodine, though capable of reducing Fehling's solution.. If this is the case, then the difference in the

behaviour of the two malts with the two reagents would be explained, as the cupric-reducing power of dextrine is much less than that of maltose. If this view is correct, then the specific rotation of the products of hydrolysis of starch should be greater with *cholam* malt than with barley malt, dextrine having a higher specific rotatory power than maltose ; whereas the cupric-reduction power would be greater in the case of barley malt.

In order to obtain information on these points, the following experiments relating to the nature of the starch conversion products of *cholam* and barley malts were carried out. O'Sullivan[1] has pointed out that in the hydrolysis of starch by barley malt more dextrine than maltose is produced at higher temperatures. It was therefore thought desirable to conduct the experiment at two different temperatures.

Twelve grams each of *cholam* and barley malts were extracted with water at the laboratory temperature (28–30°C.) for 3½ hours and filtered. Fifty c.c. of 8 per cent. soluble starch solution were taken in two 100 c.c. flasks to which 3 c.c. of the malt extracts were next added, and the whole maintained at room temperature for 3½ hours. To two other 100 c.c. flasks each containing 50 c.c. of the soluble starch, 3 c.c. of the extract were similarly added, and the whole kept at a temperature of 65–70°C. for 45 minutes only. At the end of these periods the two sets of solution were raised to the boil, cooled, made up to 100 c.c. and filtered. The percentage of total solids, the specific rotation, and the cupric-reducing power of each of the filtrates were then determined. In the table below, the cupric-reduction values (R) are referred to maltose (as is usual in the case of starch conversion products), taking that of maltose = 100.

TABLE X.

Showing the optical rotation and the cupric-reducing powers of the products of hydrolysis of starch by Cholam *and Barley malt extracts at* 28–30°*C. and* 65–70°*C.*

Factor for the starch-conversion product = 3·977.

Name of malt	Temperature of hydrolysis	% Solids	$[\alpha]_{D.\ 3\cdot977}^{20}$	R = % that of maltose
Cholam	28 – 30° C.	3·81	148·12	89·1
	65 – 70° C.	3·85	150·83	85·5
Barley	28 – 30° C.	3·79	140·13	92·0
	65 – 70° C.	3·87	141·10	90·0

[1] O'Sullivan: *J. C. S.*, T. 1876.

It is seen that the percentage of total solids in the two sets of solutions being almost the same, the specific rotation of the products of hydrolysis, both at low and high temperatures, is greater with *cholam* malt than with barley malt whereas quite the reverse is the case with the cupric-reducing power. The above experiment would thus appear to bear out the view previously expressed that the proportion of dextrine to sugar is greater in the case of *cholam* than in the case of barley malt.

It is also seen that the observation made by O'Sullivan[1] that comparatively more dextrine than sugar is formed when the hydrolysis takes place at higher temperatures (65–70°C.), is even more pronounced in the case of *cholam* than barley.

(c) *A preliminary examination of the products of starch hydrolysis by* Cholam *malt.*

It has been shown so far that *cholam* malt is diastatically more active than barley malt under the conditions of our experiments; for *cholam* to take the place of barley in malting operations, it is of importance that the starch-conversion products should be similar in both the cases. A preliminary examination, therefore, was made of the products formed as a result of hydrolysis by *cholam* malt.

Ten grams of soluble starch were stirred with 200 c.c. of boiling water, cooled, and the aqueous extract from 10 grams of *cholam* malt added. A little toluene was put into the flask, and the whole kept at laboratory temperature overnight. The next morning the liquid was raised to the boil to coagulate the proteins in the malt extract, cooled and filtered. The filtrate was reduced to a small volume on the water bath, and 92 per cent. alcohol was added to precipitate dextrine, a small quantity of which separated out as a white gelatinous mass coloured red by iodine, and was again filtered. The alcohol was distilled off *in vacuo* and the sugar solution concentrated. A portion of the concentrated syrup was made up to 100 c.c. Twenty-five c.c. of this were pipetted off into a small flask, 2 c.c. of strong hydrochloric acid were added and the sugar was hydrolysed on the water bath for one hour. At the end of this period, the hydrolysed sugar solution was cooled, neutralized with caustic soda made up to 50 c.c., and examined both by optical and copper-reduction methods. Another portion of 25 c.c. of the diluted sugar solution was made up to 50 c.c., and similarly examined for purposes of comparison.

[1] O'Sullivan, *loc. cit.*

TABLE XI.

Showing the results of examination of the starch-conversion products of Cholam *malt before and after hydrolysis.*

	Before hydrolysis	After hydrolysis	Ratio. Before hydrolysis : After hydrolysis
Schmidt and Haensch polariscope scale reading (200 m.m. tube)	+ 60·4	+ 24·0	2·52
c.c. Fehling's solution reduced by 100 c.c. of the sugar solution	52·1	80·6	0·65

It will be noticed that, after hydrolysis of the sugar solution, there is a considerable fall in the polariscope readings, and a large increase in the quantity of Fehling's solution reduced. This behaviour accords with that of maltose when hydrolysed into dextrose. The specific rotatory power of maltose and dextrose[1] being 138·0 and 52·76 respectively, the ratio of the polariscope readings before and after hydrolysis in the case of maltose solution would be $\frac{[\alpha]_D}{[\alpha]_{D'}} = \frac{138{\cdot}0}{52{\cdot}76} = 2{\cdot}62$. Similarly, the ratio of the quantities of Fehling's solution reduced would be, according to the cupric-reducing powers, $\frac{K}{K'} = \frac{61}{100} = 0{\cdot}61$. These figures correspond very nearly with those entered in column 4. It is thus clear that the solution under examination behaved as though it was one of maltose.

With phenylhydrazine hydrochloride, maltosazone and glucosazone were produced.

We propose to continue this part of the investigation.

From a consideration of the foregoing results, we feel justified in concluding that *cholam* may be used wholly or partially as a substitute for barley in malting operations. The absence of a sufficient proportion of husk in the grain is perhaps a disadvantage with *cholam*, but this defect can possibly be remedied by admixture with malted paddy or bran. *Cholam* is much cheaper and more largely available in India than barley and can, therefore, be used extensively.

Foods of the types of Mellin's food, Horlick's malted milk, malt extract, and beer were prepared by us in the laboratory and submitted to the Madras

[1] Browne, C. A. *Handbook of Sugar Analysis.*

Exhibition of 1917. The details of the methods of preparation and the nature of the apparatus used are being published as a separate paper. [1]

SUMMARY.

The results obtained so far may be summarized as follows :—

(1) *Cholam* is better suited for malting purposes than the other common South Indian cereals experimented with.

(2) *Cholam* malt extract hydrolyses soluble starch at a greater rate than barley malt extract.

(3) In the case of hydrolysis of starch by *cholam* malt the proportion of dextrine to sugar produced is greater than in the case of barley malt compared under identical conditions.

(4) The products of starch hydrolysis by *cholam* malt consist, as with barley malt, largely of maltose and dextrine.

We would like to express our thanks to Dr. W. H. Harrison for suggesting the investigation, and to Mr. M. R. Ramaswami Sivan for help during the course of this work.

[1] *Agriculture Journal of India*, vol. XIV, pt. I.

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